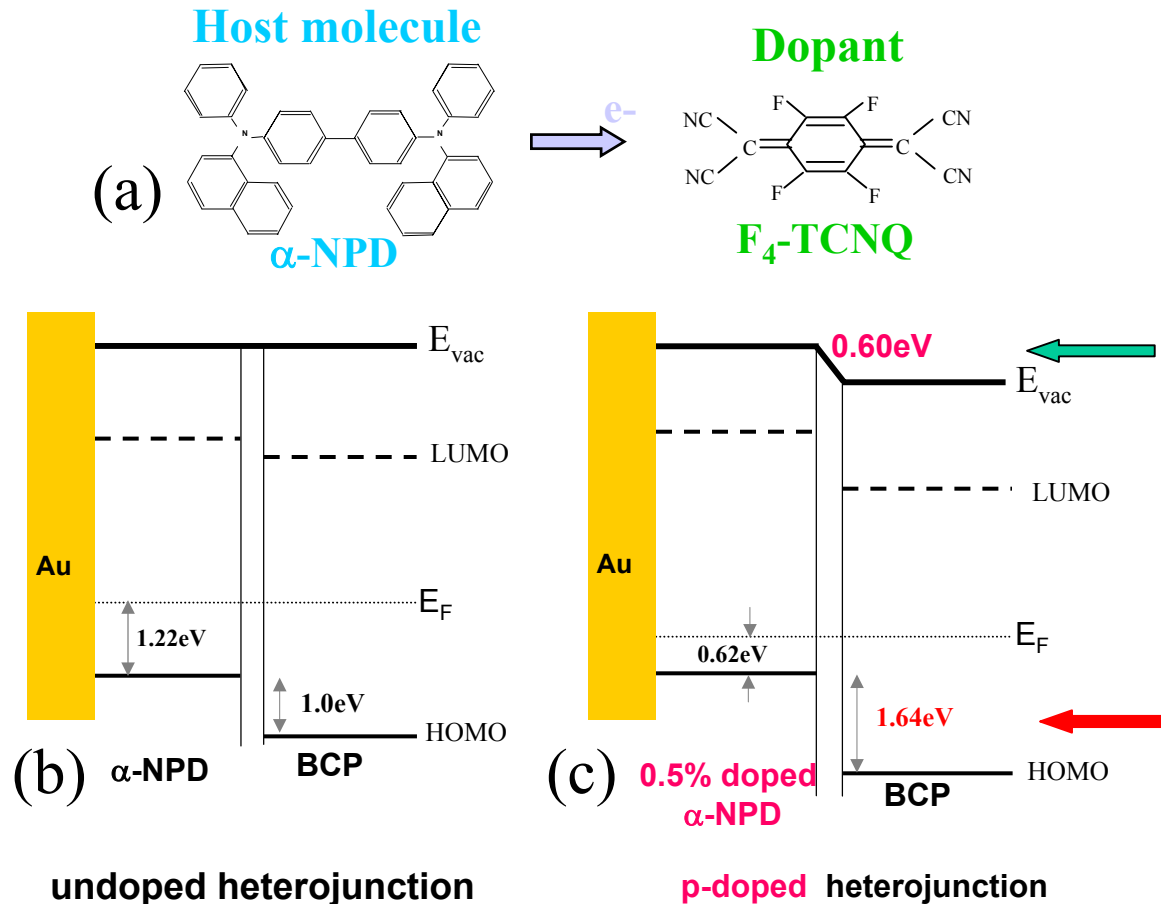


# Engineering Organic Heterojunctions Via Doping

**Antoine Kahn**, Princeton University, **DMR-0408589**

- The objective of our work is to understand the mechanisms that control the electronic structure of organic semiconductor interfaces with direct application to thin film devices, e.g. organic light emitting diodes.

- Particularly important for the transport of charges across the device is the control of the offsets between molecular levels across interfaces (here the HOMO levels, for example). We have recently demonstrated interface engineering with the use of electrical doping of one of the two organic materials, e.g.  $\alpha$ -NPD with  $F_4$ -TCNQ (Fig. a). Doping leads to a significant change in charge injection barrier. Fig. b shows a 1 eV barrier between hole transport levels (HOMO) of the two organic semiconductors  $\alpha$ -NPD and BCP. This barrier is significantly modified (1.64 eV in Fig. c) when the organic material is doped. This type change in barrier energy is potentially very important for controlling and engineering organic interfaces



This work is done in the context of our continued effort to understand and control organic interfaces. What is new here (with respect to past work on organic interfaces as well as with respect to inorganic semiconductor interfaces) is the notion that electrical doping can be used to control or tune “band offsets” at organic heterojunctions. This has potential implications, first for improving multi-layer devices, and second in terms of unraveling the mechanism(s) that control the organic-organic interface electronic structure.

In collaboration with theoreticians in Spain, we are currently working on a model that would explain the role of doping. It is too complex and irrelevant for a nugget at this point. However, the manifestation of this effect, i.e. the barrier change illustrated in the nugget, is quite important. A 0.6 eV change in barrier, such as that represented in Fig. b-c, can potentially changes current densities by orders of magnitude. Current attempts to engineer multi-layer organic devices include lowering barriers to reduce drive-voltages, or alternatively increasing barriers to create electron or hole barriers and improve the overall quantum efficiency of the device

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## Education

The outlined research is part of a broad effort developed in the PIs laboratory to understand the fundamental electronic properties of organic thin films and interfaces. The work presently involves two graduate students (Calvin Chan and Wei Zhao) in collaboration with a post-doctoral fellow (Fabrice Amy), one undergraduate senior student (Rachel Cheng), colleagues in the chemistry department, and three companies (DuPont, GE and Intel). Through this highly collaborative approach, our students are being exposed to the solid state physics and to the chemistry of these materials, as well as to the concerns of industrial laboratories working toward commercialization of organic devices. Through this work, the students also participate and present their work in international conferences, e.g. Conference on Pi-Conjugated Materials, Cornell June 04, or the up-coming AVS Symposium, California, November 04.

## Outreach



The PI leads a summer 04 session of the QUEST education and outreach program on electrical and materials. QUEST is a professional development program in science for New Jersey teachers. The program offers a unique opportunity for upper elementary and middle school teachers to enhance their personal knowledge of science by engaging in laboratory experiments led by the faculty and staff of the university. QUEST participants attend two one-week sessions that each explores a different topic area.